

**DAM AND RESERVOIR
GUIDELINES
FOR
COMMUNITY AND COUNTY
EMERGENCY ACTION PLANNING**



Prepared by

STATE OF MISSOURI

**DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY & LAND SURVEY
DAM AND RESERVOIR SAFETY PROGRAM**

**DEPARTMENT OF PUBLIC SAFETY
STATE EMERGENCY MANAGEMENT AGENCY**

SEPTEMBER 1989

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EXECUTIVE SUMMARY

These guidelines were developed to encourage thorough and consistent emergency action planning for levels of preparedness which may save lives and reduce property damage. Emergency Action Plans (EAP) should contain six elements: identification of an emergency, preventive action, notification and coordination, hazard area delineation, evacuation, and termination. Methods for prediction and detection of a dam failure should be made available. The areas affected can be identified by inundation mapping prior to failure and are critical to development of notification and evacuation plans. EAP's must be tailored to specific dams and must be in sufficient detail to foresee all possible events. The complex legal and sociological aspects need to be addressed before the emergency. Actions and responsibilities need to be identified. EAP guidelines thus need to convey this message. It is important to remember that the level of planning should be consistent with the consequences of failure and the development downstream of the dam. Listing of conditions and events which could lead to an emergency condition is critical to a successful EAP. Also needed are methods available for early detection and assessment of dangerous conditions. If at all possible, the designation of someone responsible for evaluating the emergency should be made. A procedure needs to be provided so that persons able to delay or prevent the failure and to conduct the evacuation are notified. Communication and coordination with local and State officials and agencies must be identified. Training and periodic testing should be a part of the plan, and finally the plan should be reviewed and updated in a reasonable time period.

DAM AND RESERVOIR GUIDELINES FOR COMMUNITY AND COUNTY EMERGENCY ACTION PLANNING

A. INTRODUCTION

This document provides guidelines for public officials and private citizens who must plan for emergency situations involving real or potential dam or reservoir failures. It has been prepared primarily for city/county emergency management directors who should include such planning and anticipated response actions in their jurisdiction's comprehensive "Emergency Operations Plan" (EOP).

Comprehensive EOP's should be designed to address ALL hazards that threaten a city or county, including dam or water impoundment failure. The Missouri State Emergency Management Agency (SEMA) advocates the "functional" approach to emergency operations planning. This functional planning format spells out the "who," "with what," and "how" of all critical emergency functions in time of disaster.

Each city/county "all-hazard" plan establishes procedures (duties, responsibilities and actions) for disaster response; these procedures include warning the public, evacuation, shelters, medical response, and other functions inherent in disaster planning and response. Regardless of the type of disaster, these specific functions are addressed in specific functional "annexes" of the EOP; thus the "Evacuation Annex" outlines evacuation procedures from floods, hazardous materials accidents, fires, dam failures, or other dangers such as nuclear attack. In contrast, the "Warning Annex" details how the public is to be warned of any number of potential disasters, including dam failure.

Some potential disasters -- such as dam failures -- may have unique considerations; thus, some city/county leaders may choose to incorporate all procedures from various annexes of their EOP into one document separate from the EOP. This hazard-specific document on dam failures could include more detailed planning procedures for the specific dam or reservoir under consideration; however, the hazard-specific planning document for a specific dam should not contain procedures that conflict with procedures in the all-hazard EOP.

The "Dam and Reservoir Guidelines for Community and County Emergency Action Planning" provides general guidelines for dam failure planning. It also contains specific formats for function-related actions, such as warning, evacuation, and sheltering, when developed as separate dam-specific plans, or for augmenting appendices to functional annexes to the jurisdiction's all-hazard EOP. It is hoped the Emergency Management Directors and other city and county officials will use this document in their planning efforts. The final Emergency Action Plan will include all sections from the introduction through the index with appropriate data supplied which relates to the subject dam.

B. EMERGENCY ACTION PLAN APPROVAL

The _____ Dam is an earthfill/tailings/concrete/rockfill structure in _____ 1/4 Section _____, Township _____ North, Range _____, East/West on _____ tributary to _____ Creek. The dam impounds a _____ acre lake used primarily for recreation/tailings/storage/irrigation/water supply for the owner, _____, whose address and phone number are _____. The dam was built in _____ and has been inspected by the Missouri Department of Natural Resources (DNR), Dam and Reservoir Safety Program/U.S. Army Corps of Engineers; the latest inspection was in 19____. See Appendix XIII for additional information.

Should the dam breach or release flood waters, the inundation areas affected are along _____ Creek in _____. Counties, especially the communities of _____. Figure 1 is a portion of the affected county highway map with a general outline of the areas that could be affected. Section G, Hazard Area, of this EAP contains a detailed description of the affected area based on breach analyses and flood routing.

The maintenance and operation of the dam is the responsibility of _____. Mr./Ms. _____ is the contact person at _____. After hours, contact _____. The emergency action plan has been written by the Emergency Management Director or similar official for the subject county or city of interest. Approval is required by the City Council and/or the County Commissioners. Authority for this planning guide is in Chapter 44.080 and 44.090, RSMo and the following cited City and County ordinances: _____. As a result, the authority and responsibility for the government emergency actions are directly on community elected officials. In most overlapping city - county jurisdictions, the most effective emergency management arrangement is for planned, joint use of all appropriate facilities, personnel, equipment, and resources. The basis for this is usually a written agreement specifying that all emergency actions and decisions will be jointly coordinated and decided by the Mayor and Presiding Commissioner as chief elected officials of the cooperating jurisdictions.

This EAP shall be updated annually by the Emergency Management Director of _____. City/County. Every five years, it should be reviewed by city/county chief executives with respect to the operating permit issued by the Department of Natural Resources (DNR) for dams and reservoirs. All phone numbers and personnel changes must be updated as they occur, by the Emergency Management Director. This plan should be tested initially during the first year of its implementation and thereafter every 5 years. Testing procedures can be developed in cooperation with the State Emergency Management Agency in Jefferson City.

We the undersigned, this date, acknowledge this plan as a part of the emergency operation procedure to protect life and reduce property damage in an emergency at the _____

_____ Dam in _____
_____ County.

Signature, Dam Owner

Date

Signature, Co. Presiding Commissioner

Date

Signature, Mayor of City

Date

Signature, Emergency Mgt. Dir.

Date

Signature, County Sheriff

Date

Signature, City Police Chief

Date

C. IDENTIFICATION OF EMERGENCY SITUATIONS

Identification of dam emergencies must depend primarily on local observers, because of the timeliness required in an emergency situation. Unfortunately, not all communities/counties have observers trained in observing dam emergencies. A listing of conditions that threaten dams is included to aid in identifying emergencies. The dam owner has primary responsibility for determining if an emergency exists, but the local government must assume this responsibility in the absence of the owner. Technical assistance can be obtained by contacting the Department of Natural Resources, Dam and Reservoir Safety Program; however, reliable observers who can accurately describe the conditions are needed to relate their observations to state engineers.

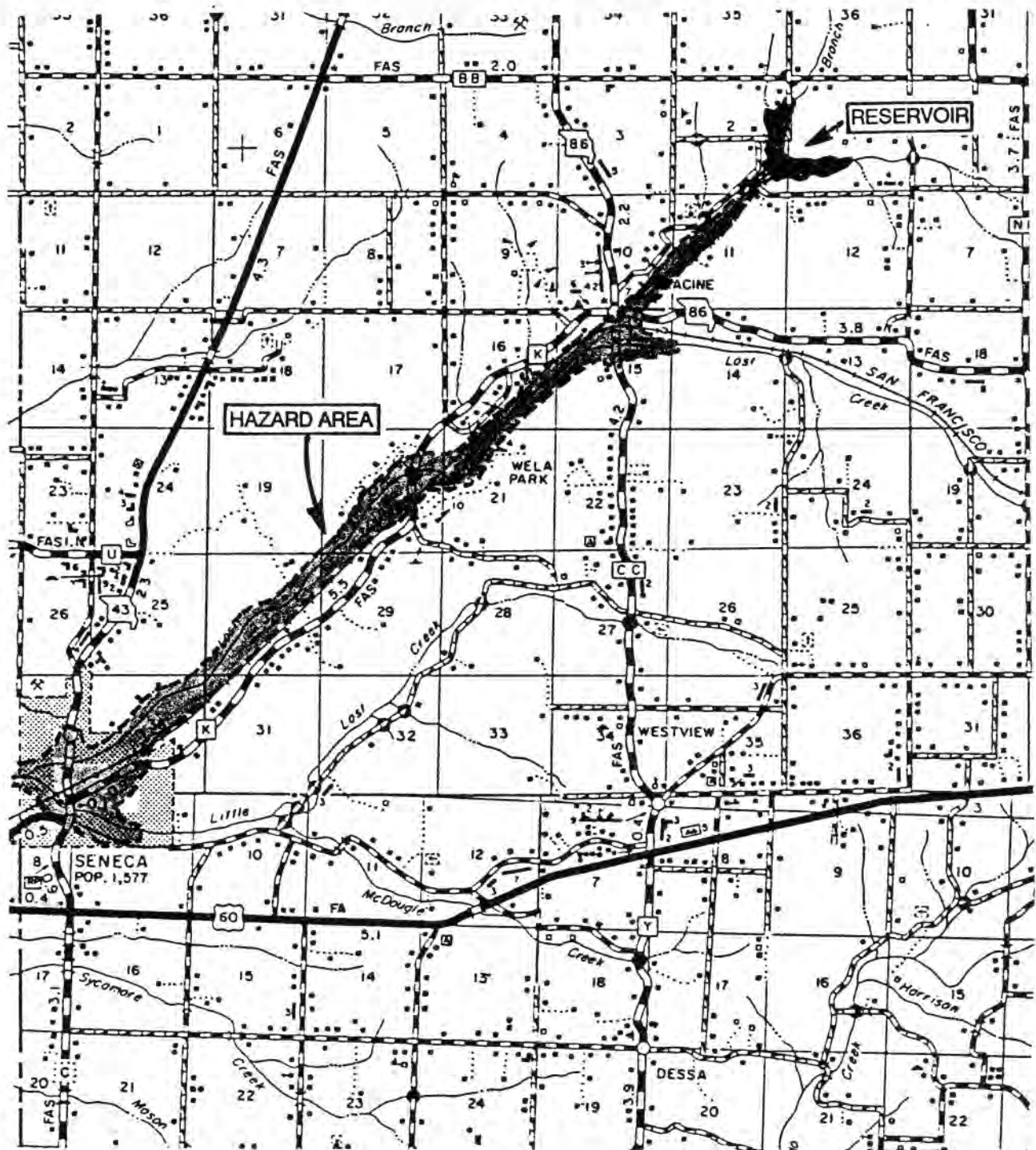


Figure 1. County highway map showing reservoir and hazard area

1. Sinkholes on Dams

Internal Erosion - Internal erosion or piping of embankment or foundation materials can cause sinkholes to develop on the dam crest or slopes. A void or seepage passageway develops that eventually collapses and forms the sinkhole. Damaged outlet pipes or separated pipe joints can cause voids. Uncontrolled seepage can also cause passageways to form. Close observation of seepage discharge can determine if seepage is carrying soil particles. Internal erosion is dangerous and can lead to total failure of a dam.

Rodent Activity - Burrowing animals digging tunnels in the dam can cause sinkholes to form when the tunnels collapse. Swimming rodents burrow into the upstream slope; other rodents burrow into the downstream slope. A collapse in the crest can reduce freeboard and cause overtopping of the dam. Corrective action is needed to prevent failure of the dam.

2. Cracks in Dams

Longitudinal Cracks - Differential movement of portions of the embankment causes cracks to develop parallel to the dam axis. This signifies a major defect and could result in slope failure. Longitudinal cracks caused by differential movement indicate uneven settlement, foundation failure, or the initiation of an embankment slide. This situation can develop into a dangerous condition.

Transverse Cracks - Differential settlement of the embankment can cause cracks to develop perpendicular to the dam axis. Generally, transverse cracks form in an area where the dam was constructed on a steep abutment slope. Subsequent to crack formation, uncontrolled seepage can develop. Reduced freeboard from settlement can increase the risk of overtopping. This is a dangerous situation, and the embankment should be repaired as soon as possible.

Drying Cracks - During dry weather surface drying can cause cracks, which are generally shallow with no signs of movement. In most cases, the crack pattern is random so that transverse or longitudinal cracks are not formed. This situation does not represent a dangerous condition.

Figure 2 shows the typical configuration of cracking in dams.

3. Mass Movements of Portions of the Dam

Rotational Slides - These are slides in which large masses of material move rotationally. The upper section moves down creating a scarp, or nearly vertical surface, and a similar mass of material is pushed out, forming a bulge at its lower section. This slide is generally caused by embankment or foundation loss of strength and changes in the saturated zone in the dam. Upstream slope instability can be caused by rapid reservoir drawdown. This instability can cause additional sliding. Generally, freeboard is lost and, in some cases, reservoir storage is released. This is a dangerous situation and could result in total dam failure.

Shallow Slides - These are caused by an overly steep slope and surface saturation of the embankment to a shallow depth. This condition generally occurs during periods of continued heavy rainfall. As a dam surface becomes saturated, the soil strength can lessen so that slides on steep slopes can result. This condition generally does not cause dam failure, because it can be repaired before a dangerous situation develops.

Slumping or Sloughing - Soil slope erosion, especially at the lower end of a slope, can cause slumping. This condition occurs on an upstream slope, due to wave erosion, and also in an area where discharge from a spillway comes in contact with an earth slope. This is easily repaired and is not an immediate threat of dam failure.

Figure 2, Signs of Distress, Shows a rotational and shallow slide in an earthen dam.

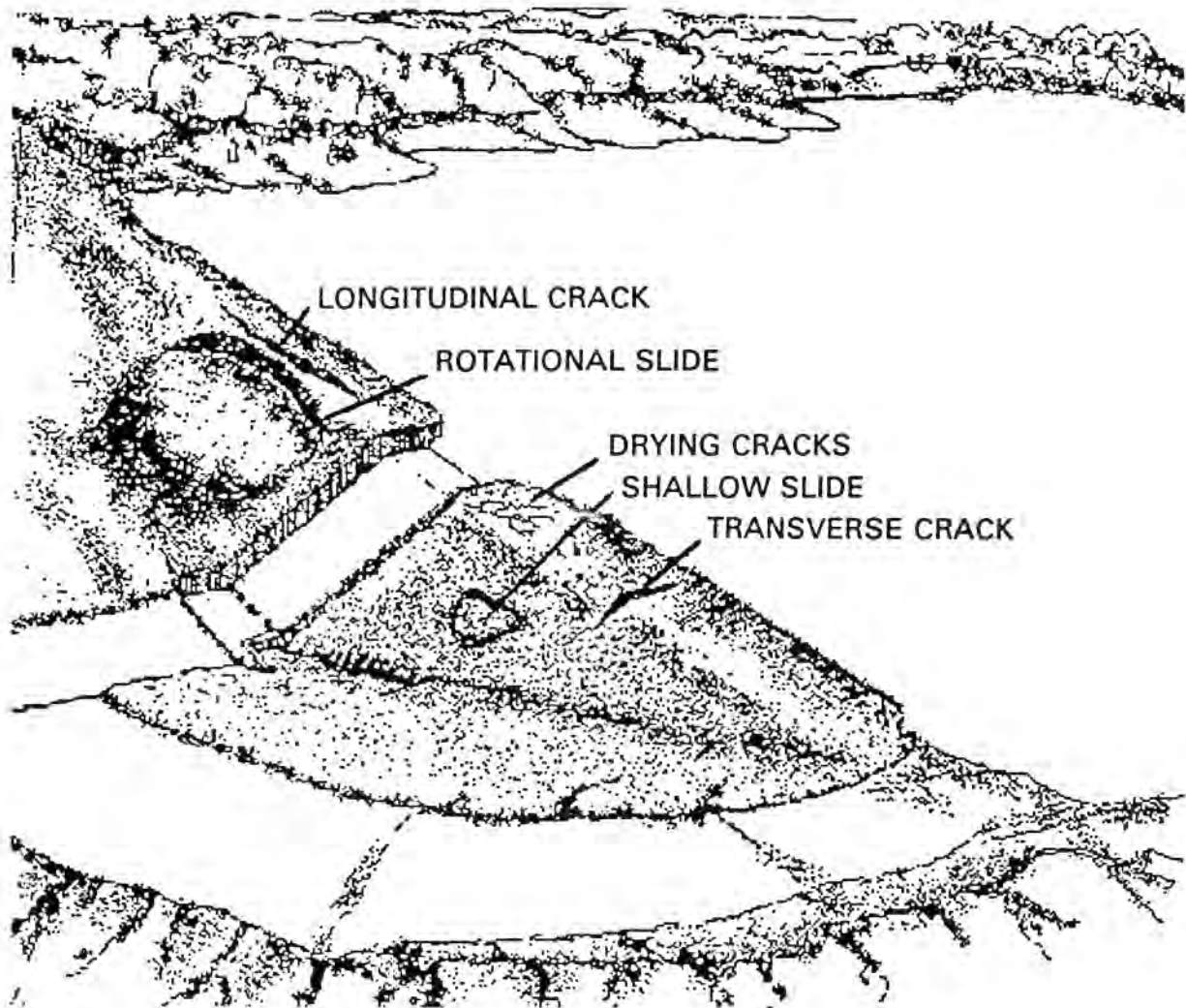


Figure 2. Signs of distress for earthen dams

4. Embankment Seepage

Concentrated Seepage - Large rates of seepage from a very small area indicate that a direct link to the reservoir has been established. This can result in internal erosion of foundation or embankment materials leading to dam failure. This is a dangerous situation and should be mitigated as soon as possible. Immediately lowering the reservoir can help prevent dam failure.

Discolored Seepage - Muddy or discolored seepage indicates that internal erosion of the embankment or foundation is taking place. This is a very dangerous situation that can rapidly lead to dam failure. Emergency measures should be instituted as soon as possible.

Seepage Over a Large Area - A large wet area indicates that a significant part of the dam has reduced soil strength because of its saturated condition. Such an area should be closely monitored for bulging, flow rate changes, clarity of discharge, and area of saturation.

5. Foundation Seepage

Concentrated Seepage - A point seepage discharge on the floodplain below the dam indicates that seepage is occurring through the dam foundation and that the cutoff wall is ineffective or has been bypassed. Movement of soil particles with the seepage means that internal erosion is taking place. Foundation and dam failure can occur if erosion is allowed to continue.

Seepage Over a Large Area - Foundation seepage can manifest itself over a large area of the floodplain below a dam. This indicates that foundation seepage is moving under the dam through a large area and velocities are fairly slow. Generally, internal erosion does not accompany this type of seepage but monitoring should be instituted.

6. Seepage Collection System

Discolored Discharge - This condition indicates the absence of a filter or filter failure in the drain system, thus allowing seepage to carry soil into the drain. This is a dangerous situation that could lead to dam failure.

Increased Flow Rate - Increased flow without discoloration indicates an increase in the operating level of the reservoir or changes in the seepage characteristics of the dam. Discolored discharge with increased seepage rates indicates a severe condition in which the drain system has failed and provided a direct connection to the reservoir. Internal erosion of the dam can result in dam failure.

7. Abutment Seepage

Generally, abutment seepage does not affect the dam. Erosion of embankment materials can occur if discharge contacts the dam.

8. Seepage Associated with Appurtenant Works

Outlet Pipes - Seepage observed in the vicinity of an outlet pipe indicates a flow path has developed along the outside of the pipe. The source of seepage is either the pipe itself or the reservoir. Pipe defects include a separated joint, a crack or break, corrosion, or a leaking valve. Such problems must be closely monitored for flow rate and discoloration.

Under Spillway Slabs - Spillway slab underseepage indicates that there is no effective cutoff. Spillway failure can result if unabated seepage continues.

9. Threatened Overtopping

Low Area on Crest - Reduced freeboard is the result of a low area on the dam crest. Low areas are caused by localized settlement, erosion, cattle paths, sinkholes, uprooted trees, transverse cracking, offroad vehicle traffic, rodent activity, and inadequate final grading of the crest during initial construction. Overtopping can cause dam failure; therefore, this condition must be repaired as soon as possible.

Inoperable Spillway - Reduced spillway capacity is caused by a damaged, blocked, or failed spillway. Improperly designed drop inlet spillways can be damaged by lake ice. Floating debris can block the spillway entrance and open channel spillways can undergo reduced capacity because of excessive vegetative growth and channel-side failure. This condition is very dangerous and can cause dam failure.

D. PREVENTIVE ACTION

1. Authorization

Preventive actions are measures that prevent or delay failure after an emergency is discovered. Because emergency actions are only stopgap measures, appropriate notification of an alert or warning of an emergency situation should be made. The dam owner should be prepared to authorize immediate expenditures, so that these actions can be taken without delay.

2. Equipment and Materials

The City/County of _____ Road Department or private contractor may have stockpiled at a location near the dam, _____ cubic yards of sand, _____ cubic yards of gravel, and _____ cubic yards of rock. Other materials such as cement, sandbags, and plastic sheeting are available at the district maintenance yard at _____.

3. Emergency Repairs

Emergency repairs can be done in a short period of time with minimum equipment and materials that will prevent or at least delay failure. After the emergency has passed, complete repairs must correct the problem. The following narrative describes actions that are emergency repairs for conditions indicated.

a. Sinkhole on Dams

If a sinkhole is caused by internal erosion, measures must be taken to stop the cause. Pipe failure or leakage can be mitigated by discontinuing use of the pipe. Otherwise, lowering the reservoir will reduce the reservoir head causing the seepage. Filling the depression is a temporary measure to gain freeboard during a storm. Fill for an active sinkhole should be an inverse filter; first rock, then gravel and sand, and finally, soil fill. The rock should be large enough not to be carried away by seepage. The rock will filter the gravel while the gravel filters the sand, etc. Sinkholes due to rodent activity should have all loose material excavated and compacted fill placed in the hole. To maintain freeboard during a storm, sandbags can be used.

b. Cracks in Dams

Cracks in the dam, with the exception of drying cracks, require reservoir draw down. Transverse cracks above the reservoir level can be sealed with clay placed at the upstream end to regain lost freeboard. Transverse cracks inundated by the reservoir and discharging water on the downstream slope should first have rock placed on the extreme downstream end of the crack. The rock must be sized so that it does not wash out but slows the flow rate. Next, gravel should be placed over the rock. Individual gravel particles should be large enough that they will not wash through the rock. Then, sand which will not wash through the gravel and finally, soil should be placed on the upstream end of the crack, sealing it. Longitudinal cracks may indicate mass movements and should be treated as a slide, except that the cracks should be sealed to prevent inflow of water. Do not use excess material that would increase the driving force causing the slide to develop further.

c. Mass Movement of Portions of the Dam

Rotational slides indicate that the dam is unstable. Even if the upper part of the slide does not intersect the upstream slope, with time, additional sliding can cause loss of freeboard. Reservoir drawdown is recommended as an immediate step. If freeboard is lost, sand bags can be added to the crest to regain lost freeboard. Sand bags, however, will increase the driving force so one must weigh the risk of continued sliding versus the risk of overtopping. If at all possible, material should be placed at the toe of the slide to provide a buttress against additional sliding.

d. Embankment and Foundation Seepage

Discolored seepage exiting from a small area of the embankment or foundation indicates internal erosion. Lowering the reservoir will decrease the seepage pressure. The best action is to construct a weighted filter over the exit point and a sand bag dike to create a backwater condition to slow the exit velocity of the seepage. Seepage exiting over a large area is not as dangerous; however, eventually it can cause instability and should be regularly monitored.

e. Seepage From Collection System

Seepage exiting from an internal drain system is collected in a controlled fashion. If discharge is discolored, it indicates that the system has failed in some manner and internal erosion is taking place. Aside from lowering the reservoir, no emergency measures can be taken. An increased flow rate indicates that reservoir levels have increased, a major problem has developed with the cutoff trench, or the cutoff trench has been bypassed. Lowering the reservoir will decrease the seepage pressure.

f. Abutment Seepage

Normally, abutment seepage does not affect dam safety unless erosion is taking place. To prevent erosion, seepage can be diverted away from the dam.

g. Seepage Associated with Appurtenant Works

Lowering the reservoir will lessen the head or eliminate spillway underseepage. Sand bagging may also help slow or stop underseepage. For seepage associated with pipes, removing the pipe from service and dewatering it is the best action. In cases where seepage is flowing along the outside of the pipe from the reservoir, no emergency actions can be taken aside from lowering the reservoir.

h. Threatened Overtopping

Low crest areas that have reduced freeboard can be sandbagged to regain lost freeboard. Inoperable spillways are extremely hard to repair or replace when the reservoir is rising. Sometimes, a backhoe can clean out debris from a spillway inlet or an open channel. Extreme care must be exercised in doing this during high reservoir levels. In other cases, another spillway channel can be excavated to increase the discharge rate; however, extreme care is needed to identify a suitable channel route.

E. NOTIFICATION AND COORDINATION

When an emergency has been identified, the local Emergency Management Director will institute the notification procedure established in the Emergency Action Plan. The dam owner is responsible for notifying local officials. In some cases, local officials will be involved in the identification of an emergency situation. The responsibility for warning and evacuating local residents belongs to local and state authorities. This responsibility also applies to other affected parties such as resorts, campgrounds, and other entities that may be located in the area. Methods of notification are listed in Appendix VIII, communications (Alert and Warning).

Radio, television, and other media should be used where appropriate. Appendix VIII lists media with coverage of the inundated area.

Two types of notices will be used. An **ALERT** situation informs affected persons that a serious situation could develop unless conditions at the dam improve. At the time the ALERT is issued,

dam failure is not thought to be imminent. A **WARNING** indicates that flooding is imminent as a result of high runoff or an impending dam failure. This would normally be accompanied by an order to evacuate the inundation zone.

Responsibility for monitoring the dam will be determined by the city Mayor and/or County Presiding Commissioner at the time this EAP is prepared. Required continuous or periodic monitoring will be conducted with regular communication made to the Emergency Management Director. Changes in the dam condition may warrant additional notifications to affected persons. Appendix VII addresses surveillance agreements and scheduling.

F. EVACUATION

State and local officials are responsible for evacuation planning and implementation. In some cases an evacuation plan may have been developed for incorporated areas in the inundation zone. This plan can be modified for flooding from dam failure and include unincorporated areas.

The evacuation plan will identify safe routes to evacuee reception areas. Bridges affected by flooding, low water crossings, secondary and main highways must be considered. A map of the inundated area should be used in announcing evacuation routes. Transportation will be by private vehicles supplemented by public transportation and local school buses. Appendix IX addresses transportation and evacuation in detail.

Reception centers are to be set up in gymnasiums at local schools, churches or civic centers. The American Red Cross will organize and run the center, assisted by local volunteers. These arrangements should be made at the time the EOP is adopted and reviewed annually. Evacuees must bring clothing if at all possible. Appendix X discusses temporary housing and shelter.

G. EMERGENCY TERMINATION AND FOLLOW-UP

Termination of the emergency will be decided by the Mayor and Presiding Commissioner and will be based on observations of the dam, the inundation area, and stream conditions. Termination of the emergency condition at the dam should be based on observations by personnel trained in design, operation, and maintenance of dams. The Dam Safety Program of DNR in Rolla should be contacted, if possible, to observe and evaluate the condition of the dam. Termination of the evacuation and disaster response activities will follow the end of the emergency condition at the dam and the actual flooding in the inundation area. Appropriate news releases will supplement other public notification regarding permitted return to the inundated area.

Security for the inundated area will be established, so that residents are allowed entry but non-residents are denied entry. During the evacuation, security must also be provided to prevent entry by non-authorized personnel to flooded areas.

The Emergency Management Director will prepare a post-emergency critique using comments from all participants. Events before, during, and after the emergency will be evaluated so that improvements and deficiencies can be identified. Findings should be used to modify the EAP.

H. HAZARD AREA

The area inundated by water released from _____ Dam during a "sunny day breach" has been plotted on Figure 1. For unincorporated areas, the map shows county, state, and federal roads, and houses, buildings, and other features. The map for the affected counties is taken from the county highway maps published by the Missouri Highway and Transportation Department.

The "sunny day breach" simulates a failure caused by a deep rotational slide or piping failure of the dam. The final configuration of the model used is a notch _____ feet wide at the top, ____H:____V side slopes and _____ feet wide at the bottom. A time to breach of _____ minutes indicates a fairly rapid development was used. No storm runoff was considered at the time of the breach, so that this type of failure during a storm would be appreciably more severe.

In some cases, incorporated areas will be inundated and inundation maps will show streets bounding the inundation zone. In other cases, the inundated area will be sparsely populated so that a narrative describing the areas flooded will be sufficient. Flooding of key points can be established and interpolation can be used to determine if a feature between these points will be flooded. Rate of travel of flooding can be described so that timing can be estimated.

REFERENCES

- Missouri Department of Natural Resources, Division of Geology and Land Survey (1986), *Maintenance, Inspection, and Operation of Dams in Missouri*, Dam and Reservoir Safety Program.
- Missouri Department of Public Safety, Emergency Management Agency (1982), *Dam & Water Impoundment Annex Guidelines for Community & County Emergency Preparedness Plans*.
- National Research Council (1983), *Safety of Existing Dams*, National Academy Press, Washington, D. C.
- United States Federal Emergency Management Agency (1985), *Emergency Action Planning Guidelines for Dams*, Interagency Committee on Dam Safety.

APPENDIX I

GLOSSARY

Abutment	That part of the side of the valley against which the dam is constructed. Right and left abutments are those on respective sides of an observer looking downstream from a dam.
Alert	A public announcement that a serious situation could develop unless conditions at a dam improve. An alert is <u>not</u> used if dam failure is believed to be imminent.
Appurtenant Works	An ancillary feature of a dam such as the outlet, spillways, etc.
Berm	A horizontal step or bench in the sloping profile of an embankment dam.
Core	A zone of material of low permeability in an embankment dam.
Core Trench	(See Cutoff Trench)
Crest of Dam	The highest dam surface, usually horizontal.
Cutoff Trench	A foundation excavation, that is filled with impervious material to form a seepage cutoff under the dam.
Dam	A barrier built across a watercourse for impounding or diverting water flow.
Drainage Area	The area that drains naturally to a particular point on a stream or river.
Drainage Blanket	A drainage layer, in the form of a blanket, directly over the foundation material.
Earthfill Dam	(See Embankment Dam)
Embankment Dam	Any dam constructed of excavated natural materials such as the following: Earth Dam - An embankment dam made up of compacted fine-grained material. Rockfill Dam - An embankment dam made up of predominantly crushed or natural rock. Tailings Dam - An embankment dam that impounds water, rock, and/or soil particles, which are a by-product of mineral extraction.
Emergency Action Plan (EAP)	A written plan of action to be taken to reduce the potential for property damage and loss of lives in an area affected by a dam failure.
Failure	An incident resulting in the uncontrolled release of water from a dam.
Filter (Filter Zone)	A band or zone of granular material used in a dam. It is graded to allow seepage to flow across or down the filter without causing migration of material from zones adjacent to the filter.
Flood Plain	An area adjoining a stream or river that has been or may be covered by flood water.
Flood Routing	An analytical procedure that determines the attenuating effect of storage on a flood passing through a channel or reservoir.

Foundation of a Dam	The natural material on which the dam is constructed.
Freeboard	The vertical distance between the normal pool level and the top of a dam.
Groin	The area along the intersection of the face of a dam with the abutments.
Incident	An event or series of events that threaten the structural integrity of a dam.
Internal Erosion (Piping)	Removal of soil particles in a dam by seepage appearing downstream as a hole or seam discharging water that contains soil particles.
Inundation Map	A map delineating the area that would be flooded in the event of a dam failure.
Leakage	Uncontrolled loss of water by flow through a hole or crack.
Low Level Outlet	A low-level opening generally used for emptying the reservoir.
Normal Pool Elevation	The water storage elevation at which water begins to discharge through the primary or principal spillway.
One Hundred Year Precipitation	The precipitation expected to be equaled or exceeded on the average of once in 100 years.
Outlet	An opening through which water can be freely discharged from a reservoir.
Piping	(See Internal Erosion)
Probable Maximum Precipitation	The maximum amount and duration of precipitation that can be expected to occur on a drainage basin.
Reservoir	An artificial lake in which water is stored.
Riprap	A layer of large rock placed in a random fashion on the upstream slope of an embankment, shoreline, or on the sides of a channel as protection against erosional damage.
Seepage	The movement of water through voids in a dam, its foundation, or its abutment.
Spillway	A structure through which flood flows are discharged. Emergency spillway - A secondary spillway designed to discharge water during exceptionally large floods. Primary (Principal) Spillway - The spillway that discharges the normal excess inflow from the drainage basin, and the first spillway used to discharge flood inflow.
Spillway Design Flood (SDF)	The largest flood that a given dam and reservoir combined can pass safely as designed. The reservoir inflow- discharge hydrograph used to estimate the spillway discharge capacity requirement and corresponding maximum surcharge elevation in the reservoir.
Sunny Day Breach	A simulated breach of a dam with the reservoir at the emergency spillway elevation. Computer methods are used to simulate the breach that progresses over a given period of time to specified dimensions. During this time, a flood wave is released from the reservoir. The flood magnitude is governed by the breach dimensions, the time for the breach to fully develop, and the size of the valley downstream of the dam.
Toe of Dam	Junction of the downstream face of a dam with the ground surface.

Training Berm	An embankment of material built to confine or guide water flow. One example would be a spillway training berm used to guide the spillway discharge below the dam.
Trash Rack	A screening device at the intake to a spillway hose. Its purpose is to prevent ingress of floating debris and allow full operation of the spillway without restricting water flow.
Underseepage	Movement of water through voids in the foundation of a dam or spillway.
Warning	A public announcement is used to notify the public that flooding is imminent as a result of unusually high runoff or an impending dam failure.
Weir	A small barrier used to measure seepage flows. Types of weirs include "V" notch, rectangular, and broad crested.

APPENDIX II

DESCRIPTION OF THE DAM

This appendix identifies the basic features of the dam, its spillways, and outlet works which may be useful in evaluating the condition of the dam or aid in any attempt to delay or prevent failure of the dam. Additional information can be found in the inspection report(s) in Appendix XIII.

Name of Dam _____ ID # MO _____

County _____ Section ____ Township ____ Range ____

Owner _____ Phone _____

Address _____

City _____ State _____ Zip _____

Type of Dam _____ Height _____

Downstream Slope Angle _____ Berms _____

Areas of Seepage on dam _____

Areas of Seepage below dam _____

Areas of Seepage on abutments _____

Crest Width _____ Freeboard _____

Internal drain system _____ Outlets _____

Vegetative cover _____ Riprap _____

Primary Spillway _____ Trash Rack _____

Outlet Basin _____ Conduit _____

Seepage _____

Emergency Spillway _____

Outlet Channel _____

Outlet Works _____ Gate Valve _____

Conduit _____ Outlet Structure _____

Seepage _____

APPENDIX III AREA MAP

The area map identifies access routes for transporting relief personnel and supplies. Major routes that can be used without being affected by flooding have been identified. Locations of the Emergency Operation Center (EOC), the dam and the inundation zone are also marked.

City/County property can be a staging area for equipment and supplies; such property should be identified on the area map with clearly shown access routes. Also shown are facilities that can house evacuees. Figure 3 is an example of an area map for a dam in Newton County.

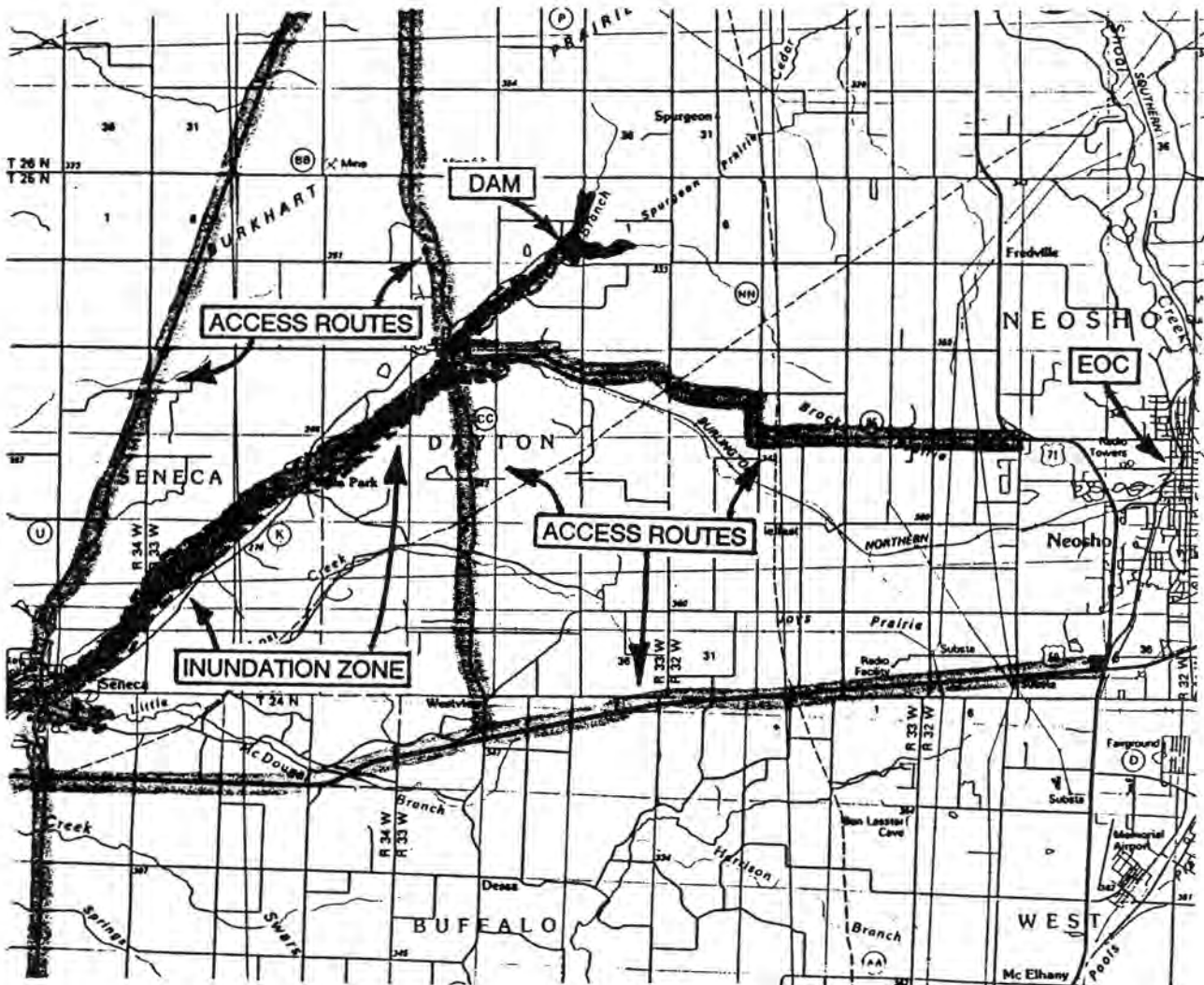


Figure 3. Area map

APPENDIX IV TRAINING

The Emergency Management Director for the City/County of _____ will be responsible for setting up a training schedule for all personnel in the Emergency Action Plan, when implemented. Personnel changes will require training new people. In addition, trained personnel should periodically review emergency procedures to implement their readiness.

Training exercises can be implemented annually as described below:

<u>Training</u>	<u>Participants</u>
Inspection of Dam	Dam Owner Emergency team observers Police/Sheriff's deputies
Drive zone below dam	Police/Sheriff's deputies Fire Units Volunteers
Meet with SEMA Officials	Mayor/Presiding Commissioner Emergency Management Director- City/County
Review equipment and material needs	State Highway and Transportation District Supervisor; City/County Roads and Streets Supervisor

APPENDIX V LOG OF ACTIVITIES

_____ DAM

1. Past Maintenance Activities

Riprap repair: _____
 Trashrack cleaning: _____
 Collect and burn debris: _____
 Repair erosion gullies: _____
 Reseed bare areas: _____
 Other: _____

2. Past Repairs to Improve Safety

Spillway upgrade: _____
 Slope stabilization: _____
 Internal drain installation: _____
 Other: _____

3. Past Emergency Actions

Lowering reservoir: _____
 Berm construction: _____
 Other: _____

4. Monitoring Activities

<u>Date</u>	<u>Measure Seepage Discharge</u>	<u>Measure Piezometers</u>	<u>Primary Spillway Discharge</u>	<u>Emergency Spillway Discharge</u>	<u>Slope Movement</u>	<u>Reservoir Level</u>
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

APPENDIX VI EMERGENCY OPERATIONS CENTER

The Emergency Operations Center (EOC) is _____
 City Hall/Council Chambers are in the City of _____
 as mutually agreed to during the preparation of this EAP. The EOC communications center is adjacent
 to the police/sheriff communication facilities.

1. Emergency Call List

Presiding Commissioner	_____ Day _____ Night
Mayor	_____ Day _____ Night
Emergency Management Director	
City _____ Day _____ Night	
Emergency Management Director	
County _____ Day _____ Night	
Sheriff's Office _____ Day _____ Night	
Police Department _____ Day _____ Night	
State Highway Patrol, Troop _____ Day _____ Night	
State Highway & Trans.	
Department Supervisor _____ Day _____ Night	
State Emergency Management	
Agency Duty Officer _____ Day _____ Night	
Pager _____	
DNR -	
Dam and Reservoir Safety Program _____ Day _____ Night	

Radio/Television Stations

<u>Call Letters</u>	<u>Community</u>	<u>Phone</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

1. Chain of Command and EOC Staff
 - a. The Chain of Command shall be
 - Mayor/Presiding County Commissioner
 - Mayor Pro Tem/Senior County Commissioner
 - Senior City Council Member/County Commissioner
 - City Police Chief/County Sheriff
 - b. EOC Operating Staff
 - Mayor/Presiding Commissioner
 - Emergency Management Director City/County
 - City Police Chief/County Sheriff
 - City/Rural District Fire Chief
 - Public Works Director
 - Director of City/County Health
 - Street and Roads Supervisor
 - National Guard Liaison
 - School Board President
 - Public Information Official
 - Water Commissioner
 - County Liaison (if city emergency)
 - City Liaison (if county emergency)
 - Disaster Service Liaison (Red Cross, Salvation Army, etc.)
 - Utilities Liaison
 - Mutual Aid Liaison
2. EOC Function Organization
 - a. Emergency operations center
 - (a) Executive Group (Mayor, Presiding Commissioner, Pro Tem and/or designee)
 - (b) Operations Coordinator (Emergency Management Director)
 - (c) Department/Agency Heads and Supervisors
 - Police/Sheriff
 - Fire
 - Public Works
 - Health
 - Welfare
 - Public Information
 - Communications/Dispatcher
 - Liaison (All)
 - b. Field
 - (a) Police and Sheriff Units
 - (b) Fire Units
 - (c) Public Works Units
 - (d) Health and Welfare Units
 - (e) Utility Trouble-Shooters
 - (f) Volunteers

APPENDIX VII

SURVEILLANCE AGREEMENT AND SCHEDULE

Extracted from the joint City-County mutual aid agreement dated _____
 Schedules to be established in consultation with DNR-Dam and Reservoir Safety Program.

1. Dam incident identified (No immediate threat of failure; no weather extremes)

City inspects	Alternating weeks	Once daily
County inspects	Alternating weeks	Once daily

2. Dam incident identified (no immediate threat of failure; weather extremes forecast)

City inspects	Alternating weeks	Three times daily
County inspects	Alternating weeks	Three times daily

3. Imminent dam failure possible

City inspects	Alternating weeks	Hourly
County inspects	Alternating weeks	Hourly

4. Failure in Progress

City inspects	Alternating weeks	Around the clock
County inspects	Alternating weeks	Around the clock

5. Volunteer Surveillance Groups
 - a. Emergency Management Organization - _____
 - b. Auxiliary Police - Contact: _____
 - c. American Legion - Contact: _____
 - d. Veterans of Foreign Wars - Contact : _____
 - e. Rural Residents - Contact: _____
 - _____
 - _____
 - _____

6. Surveillance Equipment Sources (Communications)
 - a. City/County Emergency Management Directors
 - b. Local Telephone Exchange
 - c. Rural Electric Cooperative
 - d. Other

APPENDIX VIII COMMUNICATIONS (ALERT AND WARNING)

1. Radio and Television

- a. All radio and television stations normally serving the city/county will receive alert, warning, and emergency messages from the police/sheriff's dispatcher.
- b. Backup communications provided by sheriff's/police (alternative) dispatcher in event of excessive traffic or inoperative conditions.
- c. Radio/TV stations to be notified:

<u>Call Letters</u>	<u>Community</u>	<u>Frequency /Channel</u>	<u>Phone</u>	<u>Contact</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

2. First observer on the scene, dam failure - spreads the warning by mobile radio, if available, to Mayor/Presiding Commissioner, who in turn alerts Emergency Management Director and(or) Police Chief/Sheriff. Similar procedure will be used if warning is made by hand-held radio or telephone.
3. City Alert and Warning
 - a. City sirens sounded.
 - b. Police cars criss-cross the threatened area using loudspeakers and sirens, giving alert-warning-evacuation messages.
 - c. Fire Department assists police.
 - d. Backup notification, if time permits, made by going door-to-door. Transportation for handicapped, convalescent, and elderly persons provided by pre-designated mission personnel.
 - e. Missouri Highway Patrol zone office and Troop Headquarters notified.
 - f. City Mayor notifies the State Emergency Management Agency and DNR's Dam and Reservoir Safety Program.
4. County Alert and Warning
 - a. Sheriff's Deputies initiate door-to-door notification of threatened area.
 - b. Rural Fire Department assists sheriff's deputies.
 - c. Missouri Highway Patrol zone office and troop headquarters notified.

- d. State Emergency Management Agency and DNR's Dam and Reservoir Safety Program notified by Presiding Commissioner.

5. Emergency Communications

- a. Police/sheriff communications are maintained on a 24 hour basis by regularly assigned personnel.
- b. Mobile radio and other communication of the following city/county offices and agencies are under the control of the police chief/sheriff for the duration of the emergency.

_____ Department
_____ Agency
_____ Office

- c. By prior agreement, local CB or ham radio groups can be included.

- d. Communications are maintained

(a) Between city/county

(b) City of _____

(c) County of _____

(d) State Emergency Management Agency

6. State of Missouri

- a. The Missouri State Highway Patrol Zone Office maintains _____ officers in _____ patrol cars with mobile radios.

- b. Missouri State Highway Patrol maintenance garage at _____
_____ has mobile radio resources.

APPENDIX IX TRANSPORTATION AND EVACUATION

1. Emergency Transportation

- a. The _____
Bus Company/School District has a fleet of _____ buses which are available by previous agreement for emergency evacuation.
- b. The following resources will be called up to evacuate people and to transport emergency supplies:
 - (a) _____ buses are at City/County yards at _____
_____ with drivers pre-assigned
and fuel stored at _____
_____.
 - (b) Local National Guard Armory at _____
_____ has _____ 2 1/2 ton trucks
available.
 - (c) _____ rock quarry has _____
dump trucks available at _____
_____.
 - (d) Freight Company has _____ tractor trailer rigs available at _____
_____.
- c. Police Chief/Sheriff has been designated to direct and oversee evacuation.
- d. Evacuation routes are shown on Figure 3 which is a road map of the inundation area.

2. Road Inspection

The Missouri Highway and Transportation Department Road Inspection with the City/County roads supervisor should inspect all roads and bridges to determine useability as soon as possible after failure. Re-entry will be permitted only after roads and bridges have been declared safe.

APPENDIX X
TEMPORARY HOUSING AND SHELTER

1. The _____ Community Center/School gymnasium will be equipped to handle _____ people.
 - a. Cooking and feeding facilities are available at _____
_____ if not at the shelter.
 - b. Showers are available at the shelter; if not, they are at the gymnasium at _____ school.
2. Overflow will be accommodated at the _____ school.
3. Cots, mattresses, pillows, blankets, and sheets are stored at _____

APPENDIX XI HEALTH AND UTILITIES

1. _____
County Hospital at _____
and _____
Ambulance Service at _____
provide 24 hour ambulance service with EMT personnel.
2. Potable water reserves are at _____
and water cans are stored at _____
3. City, County, and rural electric service should not be affected. If it is, standby generators are at _____
4. The designated morgue is _____
Funeral Home.
5. Civil Air Patrol and pre-designated pilot volunteers can provide emergency air surveillance of the threatened area with headquarters and operations at the _____
airport.
6. The Red Cross, Salvation Army, and other services will be on hand for assistance.

APPENDIX XII

STATE AID

1. If City/County emergency resources are inadequate or become exhausted, state aid may be requested by calling the State Emergency Management Agency (SEMA) office:
 - a. During office hours, call 314/751-9500.
 - b. After office hours, weekends, and holidays, call the Duty Officer 314/751-2748.
2. A request for state aid should provide as much information as possible, and the most complete estimate of the situation about a dam failure, to assure the most effective use of state resources.
3. SEMA will need to know, as a minimum:
 - a. exact location and identification of the dam;
 - b. if the dam has failed;
 - c. if seepage, overtopping, or other dangerous conditions exist at the dam;
 - d. if the immediate and/or downstream areas have been evacuated;
 - e. an estimate of the area inundated, or under threat of inundation; and,
 - f. your most immediate needs and possible long-term needs, (such as rescue, security, transportation, sandbagging, medical assistance, debris removal, construction equipment, water-/water purification, food, clothing, emergency housing, mortuary assistance, other).
 - g. The request should provide a call-back number, identify agencies already notified and/or on the scene, number of injured and fatalities if known, number of evacuees if known, current weather conditions, and name and telephone number of dam owner.
4. The requestor or his designee will be contacted by SEMA if additional information is needed.

APPENDIX XIII INSPECTION REPORTS

1. This appendix should include copies of available DNR-Dam and Reservoir Safety Program (DRSP) Inspection Reports. For all dams regulated by DRSP, reports of recent inspections are available from

Chief Engineer
Dam and Reservoir Safety Program
Department of Natural Resources
P.O. Box 250
Rolla, Missouri 65401
314/364-1752

The State only regulates dams 35 feet or more in height, that are not used primarily for agricultural purposes, nor owned or regulated by the federal government. There are approximately 650 regulated dams in the State.

2. During the period 1978 to 1981, 615 dams in Missouri were inspected by the Corps of Engineers. Approximately half these dams do not come under state regulation, because their height was less than 35 feet. These inspection reports are on file with DNR's Dam and Reservoir Safety Program and are available from the Chief Engineer as listed above.

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